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(71) Applicant: SCAN COIN AB
Jägershillgatan 28
S-213 75 Malmö (SE)

(72) Inventor: Howells, Geoffrey
24, Pitreavie Road
Cosham Portsmouth Hampshire, PO6 2ST (GB)

(74) Representative: Lomas, Geoffrey Michael et al
BARKER, BRETTELL & DUNCAN 138 Hagley Road
Edgbaston
Birmingham B16 9PW (GB)

(54) Coin discriminator.

(57) A coin (1) is tested for its thickness by bouncing a wave packet of ultrasound off the surface (1') of the coin, and timing the arrival of an identifiable element (7) of the reflected wave packet at a sound receiver (Rx). A zero-crossing point (7) of the reflected wave packet is used as the element, and is detected by converting the output (B) of the receiver (Rx) into a rectangular waveform (C) by using a comparator (8), and then using a microcomputer (10) with a timing function to time a particular edge of the rectangular wave. A flip-flop (11) is armed by an arm signal (D) from the microcomputer to await receipt of that pulse edge, and the time of clearing of the flip-flop is measured by the microcomputer to determine the coin thickness.

Measurements are also periodically made with no coin present of the position of the coin support surface (2) to take account of any change in position of the transmitter (Tx) and receiver (Rx).

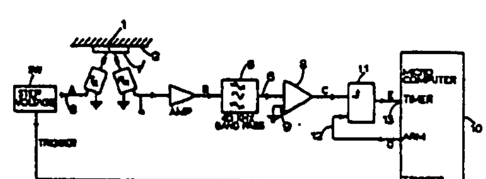

FIG.1

Description

COIN DISCRIMINATOR

This invention relates to a coin discriminator adapted to measure the thickness of a coin.

It is possible to measure the thickness of a coin using optical techniques, but such arrangements tend to suffer from a build-up of dirt on the optical components when the technique is used in a coin discriminator.

We have realised that it would be desirable to employ an ultra-sonic measuring technique. Whilst ultra-sonic measuring techniques are used in various fields for measuring relatively large objects, objects whose dimensions are many multiples of the wavelength of ultra-sonic waves, we are not aware of the use of such techniques in the coin field, where one is attempting to resolve coin thickness differences of, say, 0.1mm, as compared with the wavelength of, say, 8mm for a 40 kHz sound wave.

According to the present invention a coin discriminator comprises an ultra-sonic sound emitter and an ultra-sonic sound receiver, the emitter being arranged to direct a packet of ultra-sonic waves at one face of a coin which has its opposite face positioned against a datum surface, the receiver being positioned to receive waves reflected from said one face, and signal processing means connected to the receiver for identifying and timing the occurrence of an identifiable element of the wave-packet.

Thus, we have appreciated that by precisely timing an identifiable element of the wave-packet it is possible to detect coin thickness differences which are substantially less than the wavelength of ultrasonic sound. In effect, we are looking at the phase of the received signal.

The identifiable element is preferably a zero-crossing point of the wave of the wave-packet. For example, it would be possible to detect and time the occurrence of the second zero-crossing point in the wave-packet, suitable time reference signals being derived from the emitter.

In order to detect and time the zero-crossing point of the wave-packet received by the detector, the sinusoidal wave signal of the detected wave-packet is preferably first converted into a rectangular wave, and then a pulse edge of this rectangular wave is detected. The system is looking for an edge which occurs within a predetermined time block.

The coin is preferably arranged to roll through the coin discriminator.

A coin discriminator in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 is a block circuit diagram of the discriminator; and

Figure 2 is a plot of the signals against time at points A to E in the circuit of Figure 1.

In Figure 1 coins, such as coin 1 are allowed to roll or slide in face contact with a support surface 2 in passing from a coin insertion slot to a coin collecting region of the associated machine. Ultrasonic transmitter and receiver transducers Tx and Rx respectively have their transmitting and receiving faces located approximately 10mm from the surface 2 with their principal axes inclined at equal angles to the surface 2, such that the receiver Rx will receive a substantial reflected ultrasonic wave from a passing coin 1, or from surface 2 if no coin is present.

Typical suitable ultrasonic transducers are MURATA (T.M.) MA40S2R and MA40S2S.

A suitable transistor switch SW is employed to apply a voltage kick, shown by A in Figure 2, on the input 3 to transmitter Tx which then resonates, at 40 kHz for this particular transducer, to provide a wave packet. The wave packet reflected by the coin 1 will be received by the receiver Rx, the output 4 of which is then amplified by amplifier AMP to provide the amplified signal B shown in Figure 2. It will be seen that the amplified wave packet has the form of 40 KHz sinusoidal oscillations within an envelope which itself is of substantially sinusoidal shape.

A 40 kHz band pass filter 5 is provided to remove any noise from the signal B which can arise from the sound waves generated by some coins impacting with surface 2 or other parts of the machine.

It is desired to measure precisely changes in the time taken for the sound to pass from transmitter Tx to receiver Rx on being reflected from the surface 1′ of coin 1. In order to time precisely a zero-crossing point, such as the third crossing point 7 on the waveform B, the waveform B is converted into a rectangular waveform C by applying signal B to one input of a comparator 8, the other input A of which is earthed.

It is then required to time precisely the occurrence of the corresponding pulse edge 9 since shifts in the timing of pulse edge 9 will be produced by coins of different thickness, due to the resulting change in the total sound path between Tx and Rx. For this a microcomputer unit 10 and flip-flop 11 are provided, the microcomputer unit 10 incorporating a timing function.

Since the coin thickness differences between coins of different denominations are only fractions of a wavelength of a 40 kHz wave, the shift in the position of edge 9 for different coins is less than one wavelength and needs to be measured precisely.

An arm pulse is provided on line 12 to the flip-flop 11, the leading edge 13 of the arm pulse being produced by the microcomputer 10 at a predetermined time after the voltage step 13 in the initiating signal to switch SW, which signal is initiated on line 14 by the microcomputer 10. The flip-flop 11 will be cleared by the first rising edge of the signal C which occurs after the arming edge 13 of signal D, and accordingly the pulse edge 9 corresponding to zero-crossing point 7 will trigger the flip-flop, thereby providing the pulse of length t_1, signal E, to the timer input 13 to the microcomputer 10.

The microcomputer 10 is suitably programmed to derive a measurement of the coin thickness from the time period t_1.

The transducers Tx and Rx are conveniently mounted in respective apertures in a carrier block which is pivotally mounted with respect to surface 2, so as to enable the block to be pivoted away from surface 2 to permit cleaning of surface 2, the block then being pivoted back into an operative position in which it is held by a suitable retainer. In order to take account of the fact that the block may not always be returned to precisely the same operative position, it is arranged that a measurement of the position of the datum surface 2 relative to the transducers Tx and Rx is made whenever the associated coin apparatus is switched on, and if desired at regular times thereafter, simply be causing a pulse and measurement cycle to be performed without a coin being present at surface 2. This will provide a base time to which can be used as described below, to correct the subsequently measured time t_1 when a coin is present.

Maximum and minimum reference values of the time difference of t_0-t_1 corresponding to particular coin types are stored in a suitable memory associated with the microcomputer 10. Such reference values can be loaded into the memory in a learn mode of the device in which suitable reference coins of the various types to be identified are passed through the device, and the times t_0 and t_1 are measured, and the difference t_0-t_1 is stored. Then, in subsequent use of the device the current back plate return time to (current) is periodically measured and stored, the time t_1 (measured) for a coin under test is measured, and the difference [to (current)-t_1 (measured)] between the current stored time t_0 and the measured time t_1 is computed and is then compared with the maximum and minimum reference values of (t_0-t_1) to determine whether this measured time difference lies between the minimum and maximum reference values of t_0-t_1.

The microcomputer is looking for concordances between t_0 (current)-t_1 (measured) and the stored reference time difference maxima and minima in order to provide an identification of the coin. Often the ultrasonic test in accordance with the invention will be used in conjunction with other tests, such as on inductive test on the coin, and the microcomputer will be programmed to look for concordances involving the different reference values appropriate to the different tests.

The ultrasonic measurement technique described has the advantage over most existing optical techniques that dirt does not seriously affect the ultrasonic measurement. Whilst it is desirable to clean the surface 2 periodically, dirt should not affect the measurements made by the transducer Rx to the same extent as occurs with optical techniques. The principal reason for this is that most optical techniques involve a measurement of light intensity, whereas the ultrasonic technique described involves a measurement of the phase of the sound waves, which is not seriously affected by any dirt which might be partially blocking the reflected sound path of receiver Rx. Also the transmitter Tx and receiver Rx do not need to be as close to the coins as is generally necessary with optical techniques, and accordingly there is less chance of dirt being deposited on the transmitter and receiver by the coins.

Claims

1. A coin discriminator characterised by an ultra-sonic sound emitter (Tx) and an ultra-sonic sound receiver (Rx), the emitter being so arranged as to direct a packet of ultra-sonic waves at one face (1′) of a coin (1) under test which has its opposite face positioned against a datum surface (2), the receiver (Rx) being positioned to receive waves reflected from said one face (1′), and signal processing means (8,10,11) connected to the receiver (Rx) for identifying and timing the occurrence of an identifiable element (7) of the reflected wave-packet.

2. A coin discriminator as claimed in claim 1 in which the identifiable element of the wave-packet is a zero-crossing point (7) of the wave of the wave packet.

3. A coin discriminator as claimed in claim 2 in which the output of the receiver is converted by conversion means (8) into a rectangular wave, and the signal processing means is arranged to identify an edge (9) of the rectangular wave and to time the occurrence of that edge.

4. A coin discriminator as claimed in claim 3 in which the signal processing means comprises a flip-flop (11) which is arranged to be set by an arm pulse produced at a predetermined time following the initiation of the wave packet, the flip flop (11) being arranged to be cleared by said edge (9) of the rectangular wave.

5. A coin discriminator as claimed in any of the preceding claims in which the signal processing means comprises a filter (5) for filtering out sound noise produced by coin movement.

6. A coin discriminator as claimed in any of the preceding claims comprising zero compensation means which is arranged periodically to initiate a measurement of the position of the datum surface (2) by causing a wave packet to be initiated with no coin against datum surface (2), to produce a stored value representative of the current position of the datum surface, which is applied to the timing of a succeeding measurement on a coin to take account of possible changes in the relative positions of the datum surface (2), transmitter (Tx) and receiver (Rx).

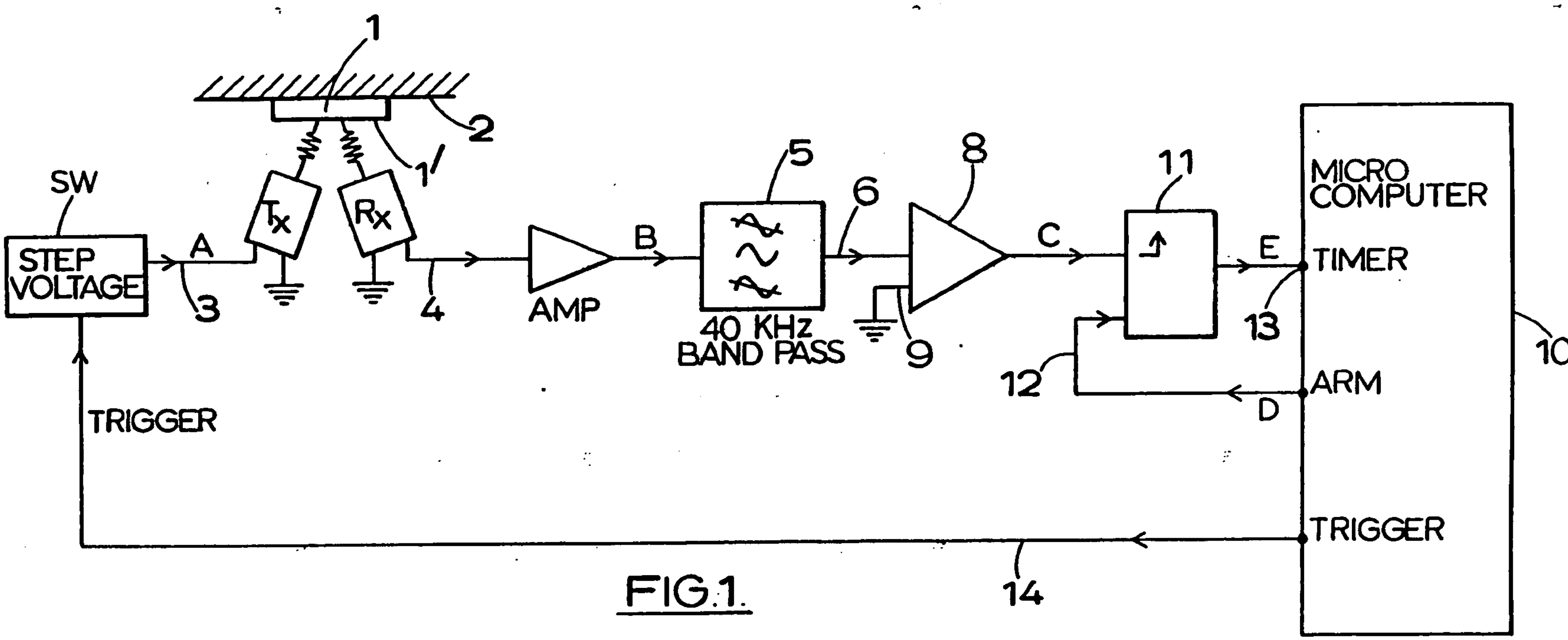

FIG.1.

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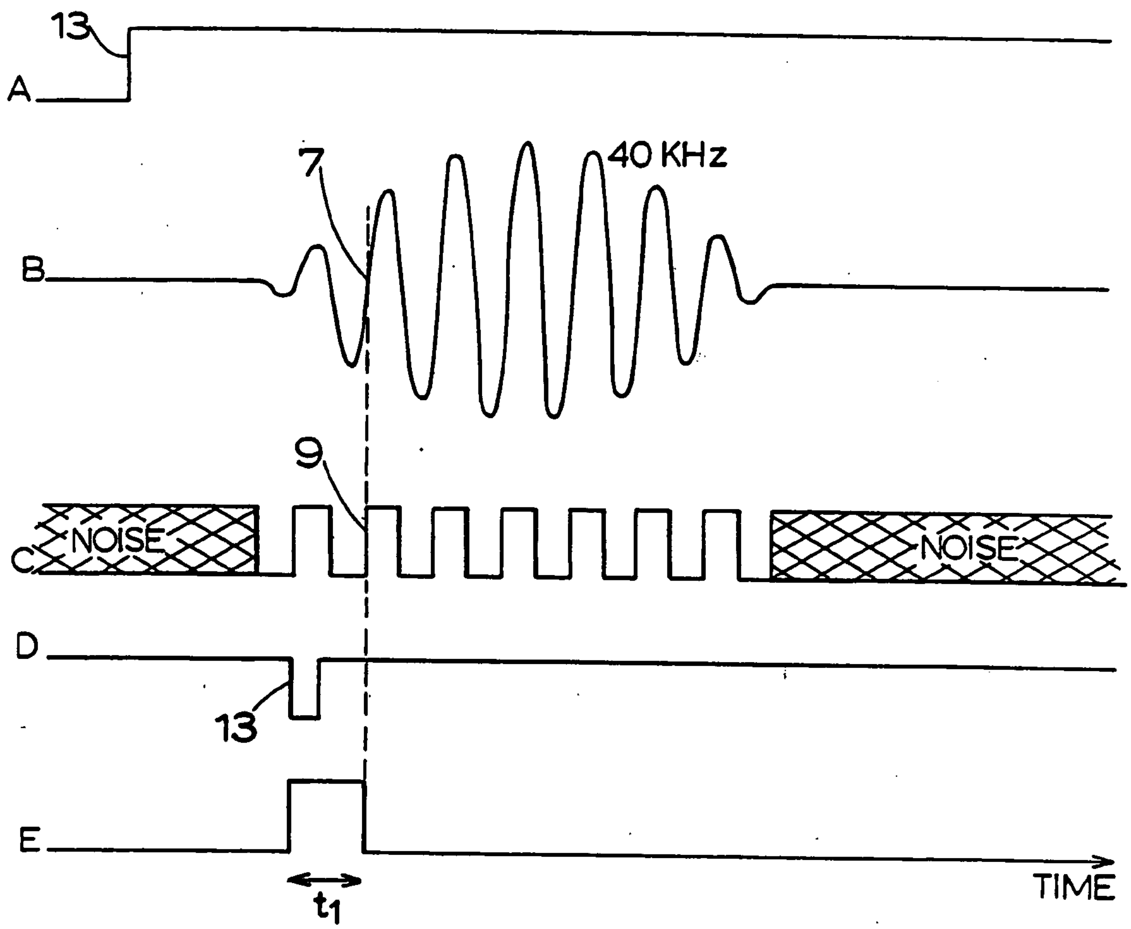

FIG.2.